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(54) **[Title of the Invention]**

POWDER AND AIR CONVEYING APPARATUS

(57) **[Abstract]**

[Object] To provide a powder and air conveying apparatus that is small and lightweight, flexible with regard to installation conditions, easy to maintain, and that enables two-way conveying.

[Constitution] A port involved in driving the powder pump main body of a powder

pump driving unit is attached to an air in-and-out opening (1ab) of the powder pump main body constructed by attaching air actuated operating valves to the openings at both ends of a body and a filter element. The powder pump driving unit controls the opening and closing of the air actuated operating valves every time the suction of air and the feeding of compressed air are performed alternately by the air in-and-out opening, and performs the suction and pressure-conveying of a powder alternately in a powder chamber at the center of the filter element.

[Scope of the Patent Claim(s)]

[Claim 1]

(a) In a powder pump main body (91) assembled by inserting a cylindrical filter element (31 or 32) inside a cylindrical body (2) provided with an air in-and-out opening (1ab) to the outside, and attaching a powder inlet-side check valve (4a1) to one opening and a powder outlet-side check valve (4b1) to the remaining opening in the openings of said two members formed at both ends, thus arranging for a hole starting in the air in-and-out opening to the outside of the body to communicate with an air chamber (7) inside the body, the primary side of the powder inlet check valve constitutes a powder inlet (5a1), the secondary side of the powder outlet check valve constitutes a powder outlet (5b1), the space formed at the center of the filter element constitutes a powder chamber (6) with the two check valves as closing ends, and the space formed on the outer circumference thereof constitutes the air chamber (7). When a flexible-film filter element (31) is used in said powder pump main body (91), the main body is assembled in a similar manner after placing a spacer (81 or 82) with a large number of air through-holes or slits between the filter element and the air chamber, to be used as a means of ensuring air permeability between the two as well as limiting the moving edge of the filter element toward the air chamber.

(b) A powder pump driving unit arranged in such a manner that the step of air being sucked in and the step of compressed air being fed are alternated at a port (x1). In a system where the air in-and-out opening (1ab) of the powder pump main body (91) described above is connected to the port (x1) of the powder pump driving unit, the air flows in the order: powder inlet → powder inlet check valve → powder chamber → filter element → air chamber → air in-and-out opening → port (x1) when the step of sucking air is underway at the port (x1), at which time the powder sucked in from the powder inlet is collected in the powder chamber; and when the step of feeding compressed air is underway at the port (x1), the air flows in the order: port (x1) → air in-and-out opening → air chamber → filter element → powder chamber → powder outlet check valve → powder outlet, at which time the air regenerates the filter element which has been clogged by the powder sucked in during the air suction step, and passes through the powder chamber as-is, working as a medium that directs the powder toward the powder outlet. A one-cylinder-type powder and air conveying apparatus installed in the powder conveying direction as described above. [Figure 1]

[Claim 2]

(a) A powder pump main body (92) modified by providing an air inlet (1a) in the middle between the secondary side of the powder inlet check valve (4a1) and the filter element fixing part on said check valve side in the powder pump main body (91) of [Claim 1].

(b) A powder pump driving unit arranged in such a manner that the step of air being sucked in and the step of compressed air being fed are alternated at a port (x1), and that the compressed air feeding step is performed at a port (x2) when the compressed air feeding step is underway at the port (x1). In a system where the air in-and-out opening (1ab) of the powder pump main body (92) described above is connected to the port (x1) of the powder pump driving

unit, and similarly the air inlet (1a) is connected to the port (x2), the air flows in the order: powder inlet → powder inlet check valve → powder chamber → filter element → air chamber → air in-and-out opening → port (x1) when the air suction step is underway at the port (x1), at which time the powder sucked in from the powder inlet is collected in the powder chamber; and when the compressed air feeding step is underway at the port (x1), the air flows in the order: port (x1) → air in-and-out opening → air chamber → filter element → powder chamber → powder outlet check valve → powder outlet, and said air mainly regenerates the filter element which has been clogged by the powder sucked in during the air suction step, and at the same time flows in the order: port (x2) → air inlet → powder chamber → powder outlet check valve → powder outlet, working as direct purge air to serve as a medium that directs the powder toward the powder outlet. A powder and air conveying apparatus installed in the powder conveying direction as described above. [Figure 2]

[Claim 3]

(a) A powder pump main body (93) modified with the attachment of air actuated operating valves (4abL) and (4abR), respectively, in place of the powder inlet check valve (4a1) and powder outlet check valve (4b1) in the powder pump main body (91) of [Claim 1], and provided with powder in-and-out openings (5abL) and (5abR) at both ends.

(b) A powder pump driving unit in which the air suction step and the compressed air feeding step are alternated at a port (x1), and a valve control air signal that correlates with the alternation is outputted at the output port of the valve control air signal.

(c) The scope of a one-cylinder-type powder and air conveying apparatus installed in the powder conveying direction, completed in that the air in-and-out opening (1ab) of the powder pump main body (93) is connected to the port (x1) of the powder pump driving unit, and in that,

when the air actuated operating valve is described by dividing it into the air actuator part and the valve part coupling therewith, the input ports of the valve control air signals of both air actuated parts are connected to the output ports of the valve control air signals of the powder pump driving unit so that both valve parts will perform mutually opposing opening and closing operations, such that when one valve part opens, the other valve part closes.

(d) In the above-mentioned scope, a valve control air signal switchover valve (19b) that can switch-over the opening and closing operations of both valve parts without changing the step when one of the steps at the port (x1) is being taken, is provided. A one-cylinder-type powder and air conveying apparatus that is reversible in the powder conveying direction as described above. [Figure 5]

[Claim 4] When the compressed air feed step is underway at port (x1) in a powder pump main body (94) modified from the powder pump main body (93) in the one-cylinder-type powder and air conveying apparatus of [Claim 3] with the provision of air inlets (1a), respectively, in the middle sections between each of the air actuated operating valves (4abL) and (4abR) and the affixing parts at both ends of the filter element, purge air is to be fed only to the air inlet (1a) on the valve closing side, at least throughout said step . A one-cylinder powder and air conveying apparatus that is reversible in the powder conveying direction as described above. [Figure 6]

[Claim 5] In the one-cylinder-type powder and air conveying apparatus of [Claim 3 or Claim 4], the relationship between the air suction step or compressed air feeding step at the port (x1) and the opening and closing operations of the valve parts of the air actuated operating valves (4abL) and (4abR) is modified as follows:

(a) when the relationship that the valve part of (4abL) closes when the valve part of (4abR) opens during the air suction step at the port (x1) is referred to as case 1, and the

relationship that the opening side is (4abL) and the closing side (4abR) is referred to as case 2,

(b) the valve parts of both (4abR) and (4abL) close in both case 1 and case 2 when the early stage of the compressed air feeding step is underway at the port (x1), and

(c) the valve opening side is (4abL) and the closing side is (4abR) in case 1, and the opening side is (4abR) and the closing side is (4abL) in case 2, when the later stage of the compressed air feeding step is underway at the port (x1). When the air suction step is underway and when the later stage of the compressed air feeding step is underway at the port (x1), as mentioned above, the valve parts of both air actuated operating valves are controlled so as to operate in the relationship that when one opens, the other closes, and when the early stage of the compressed air feeding step is underway, they are controlled such that both valves close. A one-cylinder-type powder and air conveying apparatus that is reversible in the powder conveying direction, characterized in that during the early stage of the compressed air feeding step, as mentioned above, the air chamber and powder chamber temporarily constitute an air repressurization tank. [Figure 6]

[Claim 6] A two-cylinder-type powder pump main body using two units of the powder pump main body of [Claim 1, Claim 2, Claim 3, Claim 4, or Claim 5] arranged in parallel, which is based on one combination selected from among:

(a) a combination of two of said powder pump main bodies and a powder inlet manifold (10a) that integrates their powder inlets (5a1) into a common powder inlet (5a2),

(b) a combination of two of said powder pump main bodies and a powder outlet manifold (10b) that integrates their powder outlets (5b1) into a common powder outlet (5b2), and

(c) a combination of two of said powder pump main bodies and both the powder inlet manifold (10a) and powder outlet manifold (10b).

(d) A two-cylinder-type powder and air conveying apparatus that is operated so as to run mutually differing steps in the two powder pump main bodies with at least one of the air in-and-out openings (1ab) connected to a port (x1), and the other air in-and-out opening (1ab) connected to a port (x1') in the relationship between the two-cylinder-type powder pump main body and a powder pump driving unit arranged in such a way that mutually differing steps are alternated at the ports (x1) and (x1'), i.e., the compressed air feeding step at the port (x1') when the air suction step is underway at the port (x1) and the air suction step at the port (x1') when the compressed air feeding step is underway at the port (x1) [Figure 3], or

(e) A two-cylinder-type powder and air conveying apparatus that is operated so as to run the same step in the two powder pump main bodies with both of the air in-and-out openings (1ab) connected to a port (x1) in the relationship between the two-cylinder-type powder pump main body and a powder pump driving unit arranged in such a way that the air suction step and compressed air feeding step are alternated at the port (x1). [Figure 4]

[Claim 7] In the one-cylinder-type powder and air conveying apparatus of [Claim 1 or Claim 2] wherein the powder conveying direction is fixed, or in the two-cylinder-type powder and air conveying apparatus of [Claim 6] wherein the powder conveying direction is fixed, a system wherein a check valve (4a2) is attached near a powder intake opening (5a4) of a powder suction tube (5a3) connected to the powder inlet (5a1 or 5a2), which prevents the powder sucked each time into the powder inlet during the air suction step from dropping toward the powder intake opening in a transition period to the compressed air feeding step. [Figure 4]

[Detailed Description of the Invention]

[0001]

[Area of Industrial Application] The present invention pertains to a powder and air

conveying apparatus.

[0002]

[Conventional Techniques] Here, an ejector-type powder suction and discharge apparatus has been chosen as the type thought to be closest to the present invention among the various powder and air conveying apparatuses that are currently available, and this apparatus will be described below. Said apparatus has the structure shown in simplified form in [Figure 7]. In this apparatus, an air circuit (167) of the scope shown in the dot-and-dash frame at the top right of the figure, i.e., a scope made up of a three-way valve (15b) usually in (P → A) connection which connects a port (P) to a compressed air feed means (14), an air pulse generator (18b), an ejector that is an air suction means (13) that feeds compressed air when the three-way valve (15b) is in (P → A) connection, and generates a vacuum in a vacuum generating port (U), and an air repressurization tank (21) to store the compressed air via a quick exhaust valve (20) during (P → A) connection, is located at the top; its under-portion is made up of an air chamber (7) to be connected with a port (x1), a filter element (32), a powder chamber (6), a powder inlet (5a1) with an attached powder inlet check valve (4a1), and a discharge valve corresponding to a powder outlet check valve (4b1) in this order; and this system works as follows. When the system is initially connected to the compressed air feed means (14), the air is fed to the ejector and the air repressurization tank through the three-way valve in (P → A) connection. At that time, a negative pressure is created in the powder chamber which closes the discharge valve and, as a result, powder mixed with air is sucked from an open powder vessel (111) and enters the powder chamber from the powder inlet through a powder intake tube (5a3), but the air being sucked in that is mixed with the powder continues to pass into the air chamber while the filter element keeps the powder from passing into the air chamber, thus the powder gradually accumulates in

the powder chamber. The filtering action of the filter element continues to keep the dust emitted into the atmosphere from the exhaust port of the ejector at a low level that is not detrimental to the working environment. If the air pulse generator feeds the control port of the three-way valve (15b) an air signal (y1) around the time the powder is being filled into the powder chamber, the three-way valve is brought into (A $\rightarrow$ R) connection; the compressed air being fed into the ejector is stopped and at the same time the air pulses that are generated when the air in the air repressurization tank is fed into the air chamber through the quick exhaust valve, shake off the powder stuck to the side of the filter element facing the powder chamber, and at that time the discharge valve opens and discharges the powder in the powder chamber into a tank (113) that is a "feed partner" located beneath it. The operation mentioned above is one cycle of action. The problems that may arise in the above-mentioned ejector-type powder suction and discharge apparatus are as follows:

(a) Installation Space and Weight

When the apparatus is to be attached to an indoor tank already installed with a height that almost reaches the ceiling, it must be installed after removing part of the ceiling, because it is designed to be attached to cover the powder-charging inlet of the tank. Furthermore, the apparatus is heavy, and hence not easy to move once installed.

(b) Limited Installation Conditions

It is designed to be installed at the end of the powder intake pipe, and its function is to discharge the sucked powder in an intermittent manner solely to the lower side after a particular time; hence, the sucked powder cannot be conveyed somewhere else with this site as a relay

point. Accordingly, maintenance work on the apparatus must be performed on the feed partner tank (113), and is thus fraught with the difficulty and danger of work at a high place, or the heavy apparatus must be brought down to the floor.

(c) Limited Conveying Direction

The powder conveying direction is fixed, and two-way conveying is impossible. When the powder is transferred in excess to the feed partner tank, there is no means of returning the excess to the original vessel.

(d) Batch-Mode Powder Conveying Apparatus

The fact that the powder chamber is designed with a relatively large volume indicates a batch-mode powder conveying apparatus where one cycle comprised of the powder intake step and powder discharge step of said apparatus is set up so as to take more time on the former and less time on the latter. This means that the apparatus is of a type that takes a long time to carry out the suction of the powder and discharges a large amount of powder which corresponds to the volume of the powder chamber all at once in a short time, and is thus unsuitable for use in continuously conveying the powder little by little. Moreover, if it is used for such a purpose, an efficiency problem arises in that a huge amount of air corresponding to the large volume of the powder chamber is consumed, and furthermore there is a problem concerning waste in that the powder sucked into the powder inlet (5a1) in every powder suction step is dropped into the open powder vessel (111) in every powder discharge step.

[0003]

[Problems to be Solved by the Invention] The objective of the present invention is to solve the problems mentioned above.

[0004]

[Approach to Solving the Problems]

(a) Approach to Reducing Weight and Installation Space

In the present invention, a structure is designed such that the space itself on the inner side of a filter element forms most of the powder chamber volume. This will be explained with reference to [Figure 1]. A cylindrical filter element (31) is inserted inside a cylindrical body (2), and a powder inlet check valve (4a1) and a powder outlet check valve (4b1) are installed in the openings at both ends of the two, which means that the body and filter element comprise only a double tube; a powder chamber (6) is constructed in the space on the inner side of the filter element, and an air chamber (7) is constructed in the space on the outer periphery of the filter element. As a result, the height of the filter element and air chamber can be incorporated in the height of the powder chamber in the ejector-type powder suction and discharge apparatus shown in [Figure 7]. Furthermore, because an air in-and-out opening (1ab) is provided in the cylinder part of the body (2), a powder pump driving unit can be mounted by connecting it directly from the side of the body to the air in-and-out opening, and thus the height can be reduced. Moreover, the weight can be reduced because of the portion that is compressed in size.

(b) Approach to Improving the Limited Installation Conditions

A technique similar to the operation of a reciprocating pump of the type used for liquid transport is adopted, and a structure is designed that is suitable not only for suction but also for

pressure-conveying, thereby enabling said powder conveying apparatus to be installed anywhere in a powder conveying pipe. This means that the air suction step is carried out in the arrangement where the air in-and-out opening (1ab) is connected to the air suction means (13); the powder inlet check valve (4a1) opens in [Figure 1], etc., or the valve part of the air actuated operating valve (4abL or 4abR), to be controlled to play the same role as said check valve, opens in [Figure 5 or Figure 6]; and the powder outlet check valve (4b1) closes in [Figure 1], etc., or the valve part of the air actuated operating valve (4abL or 4abR), to be controlled to play the same role as said check valve, closes in [Figure 5 or 6]. In this case, a powder mixed with air is sucked from the powder inlet (5a1) in [Figure 1, Figure 2, or Figure 4] or from the powder inlet (5a2) in [Figure 3] or from the powder in-and-out opening (5abL or 5abR) on the valve open side in [Figure 5 or Figure 6], and enters the powder chamber (6), but only the air passes through the filter element and then the air chamber (7) and is sucked out from the air in-and-out opening (1ab), while leaving the powder in the powder chamber. As opposed to this, the pressure-conveying step is carried out in the arrangement where the air in-and-out opening (1ab) is connected to the compressed air feeding means (14); the powder inlet check valve opened in the air suction step or the valve part controlled to play the same role thereof, closes; and similarly the check valve or valve part that is closed, opens. In this case, the compressed air shakes off the powder stuck to the inner surface of the filter element and thereby regenerates the filter element, and the compressed air that passes from the outside to the inside of the filter element works directly as a powder conveying medium and conveys the powder under pressure in [Figure 1, Figure 3, or Figure 5]; and the compressed air directed from the outside of the filter element to the inside is mainly provided for regenerating the filtering efficiency of the filter element, and the purge air fed to the air inlet (1a) plays a major role in pressure-conveying the powder in

[Figure 2, Figure 4, or Figure 6].

(c) Approach to Improving the Limited Conveying Direction

This is achieved by controlling the operation of the air actuated part, based on the relationship that when one of the valve parts opens in correlation with the step switchover at the air in-and-out opening (1ab), the other valve part closes in the powder pump main body, shown as (93) or (94), with the attached air actuated operating valves (4abL) and (4abR) that can prevent counterflow in any desired direction, depending on the control of the two air actuated parts with respect to each other, as shown in [Figure 5 or Figure 6]. This means that a fixed direction of powder conveying from the powder in-and-out opening (5abL) to (5abR) can be realized by controlling the operation of the air actuated parts so as to establish the relationship that (4abL) closes and (4abR) opens in the compressed air feed step, when it is assumed that the valve part of (4abL) opens and the valve part of (4abR) closes when the air suction step is underway at the air in-and-out opening (1ab). Furthermore, two powder-conveying directions from (5abL) to (5abR) and from (5abR) to (5abL), when shown in terms of the powder in-and-out openings, can be realized by installing the valve control air signal switchover valve (19b) in the middle of the air actuated control air signal passage and operating it in such a way that the open and close relationship between the opening valve and closing valve can be reversed, while the step in progress at the air in-and-out opening (1ab) is kept unchanged. The above-mentioned relationships are open and close relationships similar to those of the check valves (4a1) and (4b1) in the powder pump main body (91), such as in [Figure 1], in that the opening and closing operation of the valve parts of the mutual air actuated operating valves takes place in correlation with a switchover between the air suction step and compressed air feed step at the air in-and-out

opening (1ab), but, as opposed to this, if the valve parts of the air actuated operating valves are controlled such that both of them close at the early stage of compressed air feeding, as in [Claim 5], the air chamber and powder chamber temporarily constitute an air repressurization tank and, as a result, this contributes to the approach to achieving the weight reduction mentioned in (a) of [0004] in the sense that the air repressurization tank (21) in the ejector-type powder suction and discharge apparatus shown in [Figure 7] can be omitted.

(d) Approach to Improving the Batch-Mode Powder Conveying Apparatus

In comparison with the powder chamber volume of the ejector-type powder suction and discharge apparatus, the volume is instead reduced in the present invention. This also contributes to the approach to achieving the weight reduction mentioned in (a) of [0004]. To convey the same amount as the amount of powder conveyed in one cycle of the powder suction step and powder discharging step in the ejector-type powder suction and discharge apparatus, the number of cycles is increased in the present invention to make up for the reduced volume. In other words, the amount of powder to be conveyed in the ejector-type powder suction and discharge apparatus, where one cycle with the ratio of time required for powder suction /time required for powder discharge is 20/1, is supposed to take 5 minutes, is instead conveyed in 60 cycles in 5 minutes in the present invention, for example, supposing the ratio of one cycle is 2/1. To accomplish this, the check valve (4a2) is installed near the powder intake opening (5a4) of the powder intake pipe (5a3) connected to the powder inlet (5a1 or 5a2) in the powder and air conveying apparatuses that convey the powder in a fixed direction, thereby preventing the powder that is sucked in all at once into the powder inlet from falling toward the powder intake opening in a transition period to the compressed air feed step, and to create a state where the

powder is always present at the powder inlet. Furthermore, a higher conveying speed can be achieved by forwarding the powder alternately from two cylinders by designing the two-cylinder powder and air conveying apparatus as shown in [Figure 3].

[0005]

[Action] The action of each figure will be tabulated, respectively, in tables and explained below. Each table pertains to one cycle for operating the powder pump main body, which is completed by starting with no air signal (y1) being fed to the powder pump driving unit from outside or produced internally by the powder pump driving unit itself, and ending with the presence of an air signal. In the tables, “no” pertaining to the air signal indicates the state that the air signal is vent-connected and there is no residual pressure on the output side. Furthermore, "(–)" pertaining to the system to be connected with the air inlet (1a) indicates that it is connected to neither the compressed air feed means nor the air suction means. Furthermore, in [Figure 5 and Figure 6], the air actuated operating valves (4abL) and (4abR) are individually running-type actuators, and the valve parts to be coupled with them are usually shown as closed valves. The system shown as a powder pump drive unit in the dash-and-dot frame (161) of [Figure 1] is a typical example of an air circuit to run the powder pump main body (91) of [Claim 1]. [Table 1] shows the result of the connection of the air in-and-out opening (1ab) to the external compressed air feed means (14) or air suction means (13) depending on the "yes" or "no" of the air signal (y1) given from outside in the relationship of said powder pump driving unit with the powder pump main body (91), the open or close operation of the check valves (4a1) and (4b1), and the action of the powder pump main body. For one cycle, the length of the non-output time of air signal (y1) determines the duration of the powder intake step in the powder pump main body, and the length of output time determines the duration of the powder pressure-conveying step.

[0006] The system shown as a powder pump driving unit in the dot-and-dash frame (162) of [Figure 2] is a typical example of an air circuit used to run the powder pump main body (92) of [Claim 2]. [Table 2] shows the result of the connection of the air in-and-out opening (1ab) to the external compressed air feed means (14) or air suction means (13), and the connection or non-connection of the air inlet (1a) to the external compressed air feed system (14) depending on the "yes" or "no" of the air signal (y1) given from outside in the relationship of said powder pump driving unit with the powder pump main body (92), the open or close operation of the check valves (4a1) and (4b1), and the action of the powder pump main body.

[0007] The system shown as a powder pump driving unit in the dot-and-dash frame (163) of [Figure 3] is a typical example of an air circuit used to run the powder pump main body of [Claim 6]. [Table 3] shows the result of the connection of the mutual air in-and-out openings (1ab) to the external compressed air feed means (14) or air suction means (13) depending on the "yes" or "no" of the air signal (y1) generated internally in the relationship of said powder pump driving unit with the mutual powder pump main bodies, the step performed in the respective powder pump main bodies (91), and the action of the two-cylinder powder pump in its entirety. The air pulse-generating circuit shown in the dotted-line frame (18a) in said powder pump driving unit enables the length of non-output time and the length of output time of air signal (y1) to be regulated as desired by two delay circuits.

[0008] The system shown as a powder pump driving unit in the dot-and-dash frame (164) of [Figure 4] is a typical example of an air circuit used to run the powder pump main body of [Claim 6]. [Table 4] shows the result of the connection of the mutual air in-and-out openings (1ab) to the air repressurization tank (21) that takes on the character of an internal compressed air feed means by being connected to the external compressed air feed means (14) or to the ejector

that takes on the character of the internal air suction means (13) in a similar manner, and the connection or non-connection of the air inlet (1a) to the compressed air feed system (14), depending on the "yes" or "no" of the air signal (y1) generated internally in the relationship of said powder pump driving unit with the mutual powder pump main bodies, the step performed in the respective powder pump main bodies (91) [*sic; should be "(92)" as shown in the Table and Figure*], and the action of the two-cylinder powder pump in its entirety. Furthermore, the powder pump main body shown at the left in the powder pump main body shown in [Figure 4] is shown as the system of [Claim 7] with the check valve (4a2) installed to prevent the powder from falling into the powder intake opening (5a4).

[0009] The system shown as a powder pump driving unit in the dot-and-dash frame (165) of [Figure 5] is a typical example of an air circuit used to run the powder pump main body of [Claim 3]. [Table 5] shows the result of the connection of the air in-and-out openings (1ab) to the compressed air feed means (14) or air suction means (13) depending on the "yes" or "no" of the air signal (y1) fed to the powder pump driving unit from the outside for each connection of the valve control air signal switchover valve (19b), the open or close operation of the air actuated operating valves (4abL) and (4abR), and the action of the powder pump main body, for the example shown in the figure. Here, the upper half of the table corresponds to one cycle in the powder conveying direction, which is executed according to one of the connections of (19b) mentioned in the table, and the lower half corresponds to one cycle in the opposite powder conveying direction, which is executed according to the other connection of (19b).

[0010] The system shown as a powder pump driving unit in the dot-and-dash frame (166) of [Figure 6] is a typical example of an air circuit used to run the powder pump main body of [Claim 4] so as to satisfy the control of [Claim 5]. [Table 6] shows the result of the

connection of the air in-and-out openings (1ab) to the compressed air feed means (14) or air suction means (13) depending on the "yes" or "no" of the air signal (y1) fed to the powder pump driving unit from the outside for each connection of the valve control air signal switchover valve (19b), the connection or non-connection of the air inlets (1a) to the compressed air feed means (14), the open or close operation of the air actuated operating valves (4abL) and (4abR), and the action of the powder pump main body, for the example shown in the figure. Here, the upper half of the table corresponds to one cycle in the powder conveying direction, which is executed according to one of the connections of (19b) mentioned in the table, and the lower half corresponds to one cycle in the opposite powder conveying direction, which is executed according to the other connection of (19b).

[Table 1] KEY to Table 1: (a) presence of air signal (y1); (b) no; (c) yes; (d) system to which (1ab) is connected; (e) opening or closing operation of check valve (4a1); (f) open; (g) close; (h) opening or closing operation of check valve (4b1); (i) close; (j) open; (k) action of powder pump main body (91); (l) suction from (5a1); and (m) discharging to (5b1).

(a)	空気信号（y1）の有無	(b)無	(c)有
(d)	(1ab)が接続する手段	(13)	(14)
(e)	逆止弁（4a1）の開閉動作	(f)開く	(g)閉じる
(h)	逆止弁（4b1）の開閉動作	(i)閉じる	(j)開く
(k)	粉体ポンプ本体（91）の作用	(l)(5a1)から吸引	(m)(5b1)に吐出

[Table 2] KEY to Table 2: (a) presence of air signal (y1); (b) no; (c) yes; (d) system to which (1ab) is connected; (e) system to which (1a) is connected; (f) opening or closeing operation of check valve (4a1); (g) open; (h) close; (i) opening or closing operation of check valve (4b1); (j) close; (k) open; (l) action of powder pump main body (92); (m) suction from (5a1); and (n) discharging to (5b1).

(a)	空気信号（y1）の有無	(b) 無	(c) 有
(d)	(1ab) が接続する手段	(13)	(14)
(e)	(1a) が接続する手段	(－)	(14)
(f)	逆止弁（4a1）の開閉動作	(g) 開く	(h) 閉じる
(i)	逆止弁（4b1）の開閉動作	(j) 閉じる	(k) 開く
(l)	粉体ポンプ本体（92）の作用 (m)	(5a1) から吸引	(5b1) に吐出

[Table 3] KEY to Table 3: (a) presence of air signal (y1); (b) no; (c) yes; (d) system to which (1ab) on the left side of the figure is connected; (e) process in (91) on the left side of the figure; (f) discharging to (5b1); (g) suction from (5a1); (h) system to which (1ab) on the right side of the figure is connected; (i) process in (91) on the right side of the figure; (j) suction from (5a1); (k) discharging to (5b1); (l) action of two-cylinder powder pump main body in its entirety; (m) suction from (5a2) and discharge to (5b2).

(a)	空気信号（y1）の有無	(b) 無	(c) 有
(d)	図左側の（1ab）が接続する手段	(14)	(13)
(e)	図左側の（91）に於ける工程 (f)	(5b1) に吐出	(5a1) から吸引 (g)
(h)	図右側の（1ab）が接続する手段	(13)	(14)
(i)	図右側の（91）に於ける工程 (j)	(5a1) から吸引	(5b1) に吐出 (k)
(l)	2筒式粉体ポンプ本体全体の作用 (m)	(5a2) から吸引して（5b2）に吐出	

[Table 4] KEY to Table 4: (a) presence of air signal (y1); (b) no; (c) yes; (d) system to which both openings (1ab) are connected; (e) system to which both inlets (1a) are connected; (f) process in both (92); (g) suction from (5a1); (h) discharging to (5b1); (i) action of two-cylinder powder pump main body in its entirety; (j) suction from both (5a1); and (k) discharging to (5b2).

(a)	空気信号（y1）の有無	(b) 無	(c) 有
(d)	図左右の（1ab）が接続する手段	(13)	(21)
(e)	図左右の（1a）が接続する手段	(－)	(21)
(f)	図左右の（92）に於ける工程	(5a1) から吸引 (g)	(5b1) に吐出 (h)
(i)	2筒式粉体ポンプ本体全体の作用 (j)	両方の（5a1）から吸引	(5b2) に吐出 (k)

[Table 5] KEY to Table 5: (a) (19b) in (P → A) (B → R) connection; (b) presence of air

signal (y1); (c) no; (d) yes; (e) presence of valve control air signal (y2); (f) presence of valve control air signal (y3); (g) presence of valve control air signal (y4); (h) presence of valve control air signal (y5); (i) opening or closing operation of valve part of (4abL); (j) close; (k) open; (l) opening or closing operation of valve part of (4abR); (m) system to which (1ab) is connected; (n) action of powder pump main body (93); (o) suction from (5abR); (p) discharging to (5abL); (q) (19b) in (P → B) (A → R) connection; (r) suction from (5abL); and (s) discharging to (5abR).

(a) (19b) が (P→A) (B→R) 接続のとき		
(b) 空気信号 (y1) の有無	(c) 無	(d) 有
(e) バルブ制御空気信号 (y2) の有無	(d) 有	(c) 無
(f) バルブ制御空気信号 (y3) の有無	(c) 無	(d) 有
(g) バルブ制御空気信号 (y4) の有無	(d) 有	(c) 無
(h) バルブ制御空気信号 (y5) の有無	(c) 無	(d) 有
(i) (4abL) のバルブ部開閉動作	(j) 閉じる	(k) 開く
(l) (4abR) のバルブ部開閉動作	(k) 開く	(j) 閉じる
(m) (1ab) が接続する手段	(13)	(14)
(n) 粉体ポンプ本体 (93) の作用 (o)	(5abR) から吸引	(5abL) に吐出 (p)
(q) (19b) が (P→B) (A→R) 接続のとき		
(b) 空気信号 (y1) の有無	(c) 無	(d) 有
(e) バルブ制御空気信号 (y2) の有無	(d) 有	(c) 無
(f) バルブ制御空気信号 (y3) の有無	(c) 無	(d) 有
(g) バルブ制御空気信号 (y4) の有無	(c) 無	(d) 有
(h) バルブ制御空気信号 (y5) の有無	(d) 有	(c) 無
(i) (4abL) のバルブ部開閉動作	(k) 開く	(j) 閉じる
(l) (4abR) のバルブ部開閉動作	(j) 閉じる	(k) 開く
(m) (1ab) が接続する手段	(13)	(14)
(n) 粉体ポンプ本体 (93) の作用 (r)	(5abL) から吸引	(5abR) に吐出 (s)

[Table 6] KEY to Table 6: (a) (19b) in (P→A) (B→R) connection; (b) presence of air signal (y1); (c) no; (d) yes; (e) presence of valve control air signal (y2); (f) presence of valve control air signal (y3); (g) presence of valve control air signal (y6); (h) presence of valve control air signal (y7); (i) presence of valve control air signal (y8); (j) system to which (1a) on the (4abL) side is connected; (k) system to which (1a) on the (4abR) side is connected; (l) opening or closing operation of valve part of (4abL); (m) close; (n) open; (o) opening or closing operation of valve

part of (4abR); (p) system to which (1ab) is connected; (q) action of powder pump main body (93); (r) suction from (5abR); (s) air repressurization; (t) discharging to (5abL); (u) (19b) in (P → B) (A → R) connection; (v) suction from (5abL); and (w) discharging to (5abR).

(a)	(19b) が (P→A) (B→R) 接続のとき			
(b)	空気信号 (γ1) の有無	(c) 無	(c) 無	(d) 有
(e)	バルブ制御空気信号 (γ2) の有無	(d) 有	(d) 有	(c) 無
(f)	バルブ制御空気信号 (γ3) の有無	(c) 無	(c) 無	(d) 有
(g)	バルブ制御空気信号 (γ6) の有無	(d) 有	(c) 無	(c) 無
(h)	バルブ制御空気信号 (γ7) の有無	(d) 有	(c) 無	(c) 無
(i)	バルブ制御空気信号 (γ8) の有無	(c) 無	(c) 無	(d) 有
(j)	(4abL) 側 (1a) の接続する手段	(−)	(−)	(−)
(k)	(4abR) 側 (1a) の接続する手段	(−)	(−)	(14)
(l)	(4abL) のバルブ部開閉動作	(m) 閉じる	(m) 閉じる	(n) 開く
(o)	(4abR) のバルブ部開閉動作	(n) 開く	(m) 閉じる	(m) 閉じる
(p)	(1ab) が接続する手段	(13)	(14)	(14)
(q)	粉体ポンプ本体 (93) の作用	(r) (5abR) から吸引	(s) 空気昇圧	(t) (5abL) に吐出
(u)	(19b) が (P→B) (A→R) 接続のとき			
(b)	空気信号 (γ1) の有無	(c) 無	(c) 無	(d) 有
(e)	バルブ制御空気信号 (γ2) の有無	(d) 有	(d) 有	(c) 無
(f)	バルブ制御空気信号 (γ3) の有無	(c) 無	(c) 無	(d) 有
(g)	バルブ制御空気信号 (γ6) の有無	(d) 有	(c) 無	(c) 無
(h)	バルブ制御空気信号 (γ7) の有無	(c) 無	(c) 無	(d) 有
(i)	バルブ制御空気信号 (γ8) の有無	(d) 有	(c) 無	(c) 無
(j)	(4abL) 側 (1a) の接続する手段	(−)	(−)	(14)
(k)	(4abR) 側 (1a) の接続する手段	(−)	(−)	(−)
(l)	(4abL) のバルブ部開閉動作	(n) 開く	(m) 閉じる	(m) 閉じる
(o)	(4abR) のバルブ部開閉動作	(m) 閉じる	(m) 閉じる	(n) 開く
(p)	(1ab) が接続する手段	(13)	(14)	(14)
(q)	粉体ポンプ本体 (93) の作用	(v) (5abL) から吸引	(s) 空気昇圧	(w) (5abR) に吐出

[0011]

[Actual Examples] For the spacer to be installed when the filter element (31) made of a soft film-like material is used, a latticed cylinder (81) is used in [Figure 1 or Figure 2], and a spiral spring (82) in [Figure 3]. These may be cylinders made of a punching metal. In [Figure 5 or Figure 6], the filter element (32) is shown as being stiff enough not to be drawn into the air in-

and-out opening (1ab) in the air suction step, and not to become warped in shape in the direction of gravity on account of the weight of the powder sucked into the powder chamber (6) when the powder pump main body (93 or 94) is installed horizontally, thus no spacer is required.

[0012]

(a) A one-cylinder powder and air conveying apparatus as described in [Claim 1 or 2].

(b) A double-tube powder suction nozzle (12) as shown in [Figure 4] consisting of two tubes, i.e., an inner tube which forms a powder intake opening (5a4) at one end and a connection with a powder inlet (5a1) of the powder and air conveying apparatus at the other opposite end, and an outer tube which forms an air blow-out opening at one end on the powder suction side of the inner tube and an air feed opening (1b) at the other (opposite) end.

In a combination of the two arrangements mentioned above, a method for preventing the bag walls from sticking together by blowing air out of the air blow-out opening of the outer tube into the bag, which is decreasing in volume, to the extent of making up for the decrease in volume while sucking the powder mixed with air from the powder intake opening (5a4) of the inner tube of the double tube powder suction nozzle, in the use that is shown in the figure as an example where the air feed opening (1b) is connected to an exhaust port (z1) of a powder pump driving unit where the amount of exhaust air of an ejector as the air suction means (13) is adjusted by a flow rate control valve (22); characterized in that the air feed opening (1b) is connected to an air feed source; and in that the powder is sucked into a sealed bag (112).

[0013] In the one-cylinder powder and air conveying apparatus described in [Claim 1 or 2], the powder pump main body (91 or 92) is modified as follows: In a powder pump main body assembled by inserting a cylindrical filter element (31 or 32) inside a cylindrical body (2) provided with an air in-and-out opening (1ab) to the outside, and attaching a blind cover to one

opening [*This is presumably the exterior opening between the cylindrical body and filter element, judging from Figure 1 or Figure 2 -- Tr. Ed.*] and an inlet-side check valve (4a1) and an outlet-side check valve (4b1) to the remaining openings in the openings of said two members formed at both ends, thus arranging a hole starting in the air in-and-out opening to the outside of the body that communicates with an air chamber (7) inside the body, the primary side of the inlet-side check valve constitutes a powder inlet (5a1), the secondary side of the outlet-side check valve constitutes a powder outlet (5b1), the space formed constitutes a powder chamber (6) with both of the check valves as closing ends, and the space formed on the outer circumference thereof constitutes an air chamber (7). A one-cylinder powder and air conveying apparatus as mentioned above.

[0014] The one-cylinder powder and air conveying apparatus as described in [Claim 1 or Claim 2], wherein the check valve (4a1 or 4b1) that constitutes the power pump main body (91 or 92) is a dual plate check valve such as shown in [Figure 1] or a ball check valve as shown in [Figure 3].

[0015] The one-cylinder powder and air conveying apparatus as described in [Claim 3, Claim 4, or Claim 5], wherein the valve part associated with the powder passage in the air actuated operating valves (4abL) and (4abR) that constitute the powder pump main body (93 or 94) is of the ball, butterfly, or gate type .

[0016] The powder pump main body (91 or 92) of the one-cylinder powder and air conveying apparatus as described in [Claim 1 or Claim 2], wherein the body (2) is of the elbow type.

[0017]

(a) A one-cylinder powder and air conveying apparatus as described in [Claim 1 or 2].

(b) A pipe that forms a connection with the powder inlet (5a1) of the powder pump main body (91 or 92) at one end and a wedge-shaped powder intake opening (5a4) at the other end.

In an application where the above-mentioned two are combined and the powder in the lower layer of the powder filled in a tank is sampled, a self-digging powder sampler that performs self-digging by starting the operation with the powder intake opening (5a4) at the leading end of the pipe stuck into the surface layer of the powder, and brings the leading end of the pipe to the lower layer of the powder while discharging the dug-up powder to the surface layer.

[0018]

[Advantages of the Invention]

(a) Small and Lightweight

An apparatus that completes one cycle by sucking a large volume of powder over a long time and then discharging this powder all at once cannot avoid having at least a large powder chamber, but the present invention is an apparatus of the type that conveys the same volume by repeating one cycle consisting of a powder suction step and a powder pressure-conveying step many times, and thus enables scale-down. Furthermore, the very space inside the filter element constitutes a powder chamber, and the size can be compressed by adopting a structure that occupies most of the volume of the inner space, and at the same time the weight can be reduced.

(b) Favorable Powder Conveying Conditions

In the powder pump main body of the present invention, the inner diameter of the powder chamber can be made equal to or even less than the inner diameter of the pipe on the powder

suction side or the pipe on the powder discharging side, and furthermore the pressure loss and friction can be reduced by the use of a structure where the powder passes linearly through the powder chamber.

(c) Favorable Installation Conditions

As long as the conveying conditions such as the physical properties and conveying distance of the powder are satisfied, any place in a powder conveying pipe can be chosen to install the apparatus, and said apparatus can be installed anywhere from one end to the other end of the powder conveying pipe. The installation direction is also highly flexible, and it does not matter whether the pipe arrangement is vertical or horizontal as long as there are no problems with respect to the opening and closing operation of the inlet or outlet check valves. Moreover, in the case of a powder pump main body using air actuated operating valves, the powder can be handled well even if the apparatus is used in a vertical pipe arrangement.

(d) Ease of Maintenance

The relatively heavy powder pump main body has a simple structure, hence, when any problems occur, they are easy to pinpoint. When there are no problems with the powder pump main body, maintenance work can be carried out by removing the light powder pump driving unit.

(e) Two-Way Transfer

Two-way transfer is enabled with the use of a powder pump main body using air actuated operating valves.

(f) Many Different Combinations are Possible

Flexibility is great, for example, a mixture of different powders can be conveyed by constructing a two-cylinder-type arrangement with an attached powder outlet manifold; continuous transfer can be achieved by constructing a two-cylinder-type arrangement with an attached powder inlet manifold and a powder outlet manifold; and a self-digging powder sampler can be constructed.

(g) Simplification of Peripheral Facilities

Dust collectors such as cyclones and back filters required for general powder and air conveying apparatuses are no longer necessary.

[Brief Description of the Figures]

[Figure 1] Figure 1 shows a partial sectional view of the powder pump main body and a diagram of an air circuit example of the powder pump driving unit in the one-cylinder powder and air conveying apparatus of [Claim 1] of the present invention.

[Figure 2] Figure 2 shows a partial sectional view of the powder pump main body and a diagram of an air circuit example of the powder pump driving unit in the one-cylinder powder and air conveying apparatus of [Claim 2] of the present invention.

[Figure 3] Figure 3 shows a partial sectional view of a powder pump main body of combination (c) as described in [Claim 6] constructed with the use of two powder pump main bodies (91) and a diagram of an air circuit example of the powder pump driving unit in the two-cylinder powder and air conveying apparatus of [Claim 6] of the present invention.

[Figure 4] Figure 4 shows a diagram of an actual example where a powder pump main

body of combination (b) as described in [Claim 6] is constructed with the use of two powder pump main bodies (92) and a diagram of an air circuit example of the powder pump driving unit in the two-cylinder powder and air conveying apparatus of [Claim 6] of the present invention.

[Figure 5] Figure 5 shows a partial sectional view of the powder pump main body and a diagram of an air circuit example of the powder pump driving unit in the one-cylinder powder and air conveying apparatus of [Claim 3] of the present invention.

[Figure 6] Figure 6 shows a partial sectional view of the powder pump main body and a diagram of an air circuit example of the powder pump driving unit in the one-cylinder powder and air conveying apparatus of [Claim 4 or Claim 5] of the present invention.

[Figure 7] Figure 7 shows a schematic diagram of an actual example of an ejector-type powder suction and discharge apparatus and a diagram of the air circuit of the driving unit (167).

[Description of the Symbols]

(1ab): air in-and-out opening

(1a): air inlet

(1b): air outlet

(2): body

(31): cylindrical filter element in the form of a film

(32): cylindrical filter element with considerable stiffness

(4a1): powder inlet-side check valve

(4a2): check valve near the powder intake opening

(4abL): air actuated operating valve

(4abR): air actuated operating valve

(4b1): powder outlet-side check valve

(5a1): powder inlet

(5a2): integrated powder inlet

(5a3): powder suction-side pipe

(5a4): powder intake opening

(5abL): powder in-and-out opening

(5abR): powder in-and-out opening

(5b1): powder outlet

(5b2): integrated powder outlet

(5b3): powder discharge-side pipe

(6): powder chamber

(7): air chamber

(81): latticed spacer

(82): spacer in the form of a spiral ring

(91): one-cylinder powder pump main body

(92): one-cylinder powder pump main body provided with an air inlet

(93): one-cylinder powder pump main body

(94): one-cylinder powder pump main body provided with an air inlet

(10a): powder inlet manifold

(10b): powder outlet manifold

(111): powder-containing open vessel

(112): powder-containing bag

(113): tank

(12): nozzle

(13): air suction means

(14): compressed air feed means

(15a): three-way valve usually in (A → R) connection

(15b): three-way valve usually in (P → A) connection

(15c): usually open three-way valve

(15d): usually closed three-way valve

(161): air circuit example of powder pump driving unit

(162): air circuit example of powder pump driving unit

(163): air circuit example of powder pump driving unit

(164): air circuit example of powder pump driving unit

(165): air circuit example of powder pump driving unit

(166): air circuit example of powder pump driving unit

(167): air circuit of driving unit of ejector-type powder suction and discharge apparatus

(17): check valve of air circuit

(18a): air pulse-generating circuit adjustable in output time and non-output time

(18b): air pulse generator

(19a): four-way valve usually in (P → A) connection

(19b): valve control air signal switchover valve

(20): quick exhaust valve

(21): air repressurization tank

(22): flow rate control valve

(23): AND element

(U): vacuum-generating port of ejector

(x1): port involved in driving the powder pump main body of powder pump driving unit

(x1'): port involved in driving the powder pump main body of powder pump driving unit

(x2): port involved in purge air feeding of powder pump driving unit

(x2'): port involved in purge air feeding of powder pump driving unit

(y1): air signal

(y2): valve control air signal

(y3): valve control air signal

(y4): valve control air signal

(y5): valve control air signal

(y6): valve control air signal

(y7): valve control air signal

(y8): valve control air signal

(z1): port involved in purge air feeding into nozzle (12)

(z2): exhaust port